

Classification of Electrical Equipment, Building 1008F, PHENIX Gas Mixing House

*A code analysis of electrical equipment
ignition potential for the flammable gas-
mixing house at PHENIX*

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Introduction

In August of 2004 the Occupational Health and Safety Administration issued a report titled "Report of Findings of the Comprehensive Occupational Safety and Health Audit of Brookhaven National Laboratory." One of the findings from the audit raised concerns over the possible electrical ignition sources in the flammable gas mixing room at Building 1008. The OSHA citation was general. This report evaluates the potential hazards using nationally recognized codes and standards.

The OSHA Concern

The following is the OSHA concern from the 2004 report:

"Equipment such as overhead fluorescent lights and electrical comfort heaters was installed in hazardous (classified) locations when it was not intrinsically safe, approved for those locations, or safe for those locations. For example, some unapproved equipment was found in a building that was used to mix flammable gases such as methane, ethane, and isobutene with inert gas. An accidental rupture of the line(s) coming into the building could create an explosive environment."

Executive Summary

OSHA regulations refer to the concept of classified (hazardous) locations, but do not define the three dimensional boundaries in which ignition sources are a concern. Nationally recognized guidelines are available to aid in engineering the boundaries. During design of Bldg 1008F, the hazards of ignition sources were reviewed and the facility design to safely accommodate flammable gas use parameters consistent with the nationally recognized guidelines. The building's safety systems exceeded requirements with the installation of detection systems and automatic shutdown features of ignition sources (electrical circuits) and fuel supplies (gas feeds). The facility has a level of protection consistent with protection objectives.

Facility Description

General Building Information: Building 1008 F is located at the PHENIX complex of RHIC, 10 feet south of Building 1008's Experimental Hall. The building is a one story, insulated metal skin building with the approximate exterior dimension of 20 ft. wide by 40 ft. long. Interior walls are finished in gypsum board. A suspended ceiling is provided. The interior space is divided into two sections. A 15 ft. by 20 ft. section is used for control equipment. The control equipment area is provided with HAVC equipment. A second area, 25 ft. by 20 ft., is used for process equipment. The process equipment contains flammable gases. The dividing wall between the controls area and the process area is a one-hour fire rated assembly with a normally closed door. See Figure 1 for a key plan.

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Figure 1 Bldg 1008F Gas Mixing House

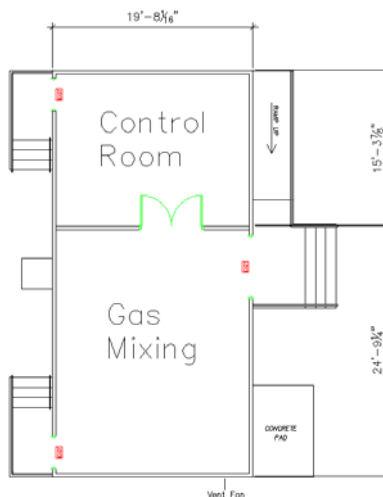


Figure 2 Bldg 1008F

Gas Systems: Building 1008F does not contain any flammable gas storage cylinders or flammable gas storage vessels. Gas pressures are shown in Table 1. Gas Supply pressures are pressure coming in from the Gas Pad. “Pressure to racks” represents gas pad supply pressures, which are reduced as they enter the building. Further reductions occur with the racks as the gases are blended. Gas system pressures are under 100 psi, these pressures are considered “low pressure”¹. There is minimal chance of mechanical damage to these pipes.

Gas	Pressure from Gas Supply (psi)	Pressure to Racks (psi)	Pressure from racks to 1008 (psi)
CO ₂	75	30	2
Argon	50	30	2
Nitrogen	40	40	20
Methane	60	20	<1
CF ₄	70	18	2
Ethane	50	15	<1
Helium	40	25	<1
Isobutane	40	15	2
Xenon	15	18	<1

Table 1 Gas pressures for Bldg 1008F equipment

Note: Highlighted gases are considered flammable

Piping within the Mixing Room is copper or stainless steel. Fittings are either soldered or compression types. All systems are designed for an order of magnitude higher in pressure than the normal working pressure. Finished installations were leak tested prior to introducing flammable gases. The experimental gas must have high purity for operations. Small leaks introduce impurities. Operational requirements drive the need to protect against leaks.

Relief valves are provided to protect against over pressurization of the equipment. All discharges from pressure relief valves are piped to the exterior of the building.

The variety of gases are blended in the gas mixing room and then transferred to the experimental hall. Cabinets are used to house equipment within the gas mixing room.

¹ NFPA 497, “Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas,” 2005, Chapter 5.7.4

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Cabinets contain valves, pumps, regulators, pressure sensors, and equipment to monitor the gas. Cabinets are extensively vented to allow the free exchange of air with the room and avoid build up of flammable gases within the rack in the event of a leak.



Figure 3 Typical vented cabinet



Figure 4 Typical piping and combustible gas detector

Mixing Room Ventilation: The gas mixing room is provided with constant ventilation. A squirrel cage exhaust fan with a non-sparking impeller, meeting Class I Division II requirements, provides at least one CFM air change per square foot of floor area per minute. The actual air exchange is 5 to ten times higher than required. Loss of flow for the fan will result in shutdown of all gas supplies.

Gas Detection: A flammable gas detection system is provided in the mixing room. Four sensors are located in the facility to detect leaks. Alarm points are set at 3% of the Lower Explosive Limit (LEL) for early warning and 5% of the LEL for shutdown. These set points are lower than the normal 10% and 25% setting established by OSHA. Automatic shutdowns include the gas supplies to the room and all electrical power except for the emergency lights. Local alarms are provided. The detection system is in the RHIC maintenance program.

Electrical: Ordinary florescent lighting equipment is present at the ceiling of the gas mixing room. Ordinary electrical devices, such as electrical outlets, electrical baseboard heaters, light switches, and electrically operated valves are installed in the room.

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Fire Systems: Fire Alarms are connected to the Site Fire Alarm System and will summon the Fire Department. Manual fire alarm pull boxes and local alarm bells are provided.

Relevant Code Citations

OSHA: The OSHA concern the 2004 report did not include a specific paragraph within CFR 1910 that was violated nor did it include any basis for what areas should have been classified. Verifying the exact OSHA citation was done by an extensive search of CFR 1910. The only relevant citation that was found was in OSHA 1910.307(a), which reads as follows:

1910.307(a)

“Scope. This section covers the requirements for electric equipment and wiring in locations which are classified depending on the properties of the flammable vapors, liquids or gases, or combustible dusts or fibers which may be present therein and the likelihood that a flammable or combustible concentration or quantity is present. Hazardous (classified) locations may be found in occupancies such as, but not limited to, the following: aircraft hangars, gasoline dispensing and service stations, bulk storage plants for gasoline or other volatile flammable liquids, paint-finishing process plants, health care facilities, agricultural or other facilities where excessive combustible dusts may be present, marinas, boat yards, and petroleum and chemical processing plants. Each room, section or area shall be considered individually in determining its classification. These hazardous (classified) locations are assigned six designations as follows: ...”

OSHA does not provide a mythology for determining the classification of rooms, sections or areas. Only after a room, section or area has been classified, does CFR 1910 start to detail what equipment is suitable for the areas.

National Fire Protection Association: NFPA 497, “Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas” provides extensive guidelines for providing proper protection to minimize ignition of gases. Guidelines are not definitive and must be used with engineering judgment. The classification must be acceptable to the Authority Having Jurisdiction (AHJ). For BNL, Fire Protection Engineering is the AHJ for defining boundaries of electrical classifications. For DOE, the AHJ resides in DOE’s Chicago Office.

Definitions from NFPA 497 For reference, the following definitions are provided:

Classified locations are those in which flammable gases or flammable vapors, are or may be present in air in quantities sufficient to produce ignitable mixtures. These locations are subdivided into two categories -Division 1 and Division 2.

Class 1 Division 1 is a location where flammable vapors are normally present. An introduction of an ignition source would result in ignition.

Class 1 Division 2 is a location where flammable vapors are not normally present, would be present only in an accident or under unusual operation conditions. An explanation of Class 1 Division 2 is provided in NFPA 497 as follows:

Adequately ventilated locations where flammable liquids and gases are contained in suitable, well maintained closed piping systems which include only properly protected pipe, valves, fittings, flanges, and meters. Exception: Systems where

valves are frequently operated such that leakage at valve packing, etc., is to be expected.

Experience has shown that the release of flammable gases or vapors from some operations and apparatus occurs so infrequently that it is not necessary to provide special precautions in the surrounding locations. For example, it is generally unnecessary to provide special precautions in the following locations:

Low, Moderate, and High Pressures For the purposes of NFPA 497, pressures are considered “low” if less than 100 psi, “moderate” if between 100 and 500 psi, and “high” if greater than 500 psi.

Analysis

The first key point is that these gas systems are low pressure. More over, the pressures are most likely in the very low-pressure ranges.

The second key point is that these are gases and not liquids. When a liquid leaks, it can evaporate and produce a large quantity of flammable vapor mix. The mix being heavier than air. Bldg 1008’s gases will not expand to produce more vapor mix and are not heavier than air in most cases.

Third key point is that room is very well ventilated. The ventilation draws across the room to the fan. The constantly running fan exceeds the minimum requires by a factor of 5 to 10.

NFPA 497 provides a series of diagrams that depict conditions that might be encountered. The following graphic depicts the most relevant arrangement for Bldg 1008F. It is for an adequately ventilated building, handling low and moderate pressure flammable liquids. It is important to note that gases have a lower release potential that flammable liquids, the opening that a release would emanate from will not be akin to a manhole or open valve, the gas will dissipate faster than flammable liquids and will not accumulate at the floor level.

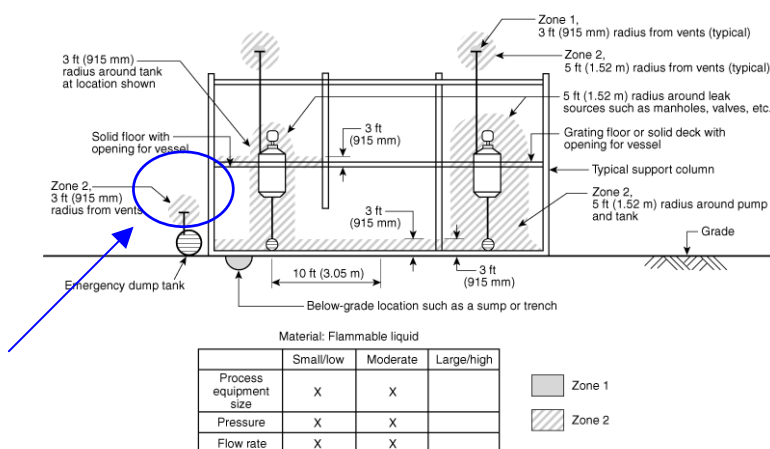


FIGURE 5.10.1(n) Multiple Sources of Leakage, Located Both at and above Floor Level, in an Adequately Ventilated Building. The material being handled is a flammable liquid.

Figure 5 NFPA 497- 2004, Figure 5.10.1(n)

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Based on the representative graphic a 3-foot boundary is needed around potential leakage points. With in the 3-foot boundary, electrical equipment must have Class I Division II rating if they are within the boundary. A typical cabinet interior is shown below.



Figure 6 Interior of rack

Once the 3-foot boundary for Class I Division II has been established, the Article 501 of the National Electrical Code is explicit regarding acceptable electrical equipment within the 3-foot boundary. In general ordinary wiring can be used. Meters and solenoids can be used, as long as they are sealed. Enclosed motors can be used. All devices must not contain spark producing contacts or slides. All equipment must operate below the ignition temperature of the flammable gases. These conditions have been met for the installation at Bldg 1008. Lighting equipment and various other ignition sources cited by OSHA are not within the range of the classified boundaries for the racks.